

**Claims:**

A listing of the entire set of pending claims is submitted herewith per 37 CFR 1.121. This listing of claims will replace all prior versions, and listings, of claims in the application.

**Listing of Claims:**

1. (canceled)

2. (currently amended) A 2 x 2 wireless local area network, comprising: a first and a second single input single output (SISO) system respectively having a first and second transmitter antenna that transmit a first and second transmitted signal  $s_1$  and  $s_2$ ; a first and second receiver antenna that receive a first and second received signal  $r_1$  and  $r_2$ ; and a demapping and signal separation module that employs zero forcing (ZF) to guide maximum likelihood (ML) decoding and is connected to said first and second SISO system and is adapted to process said first and second received signal, wherein a data transmission rate of the 2 x 2 system is greater than 100Mbps at a bit error rate of  $10^{-4}$  and a computation cost for decoding on the order of the decoding cost for an optimal SISO system;

~~The 2 x 2 system of claim 1, wherein the demapping and signal separation module employs zero forcing (ZF) of the first and second received signal, respectively, which received signals correspond to~~

$$\begin{pmatrix} r_1 \\ r_2 \end{pmatrix} = \begin{pmatrix} h_{11} & h_{21} \\ h_{12} & h_{22} \end{pmatrix} \begin{pmatrix} s_1 \\ s_2 \end{pmatrix} + \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}$$

and results in the first and second transmitted signal being calculated as

$$\begin{pmatrix} \tilde{s}_1 \\ \tilde{s}_2 \end{pmatrix} = \begin{pmatrix} h_{11} & h_{21} \\ h_{12} & h_{22} \end{pmatrix}^{-1} \begin{pmatrix} r_1 \\ r_2 \end{pmatrix}$$

and finds the minimum Euclidean distance between the ZF calculated symbol and a constellation point to estimate by hard decision the first and second transmitted signal as first and second estimated signal as  $\begin{pmatrix} \hat{s}_1 \\ \hat{s}_2 \end{pmatrix}$  which are then used to guide the maximum likelihood (ML) decoding,

wherein,  $h_{ij}$  represents a channel from the  $i^{\text{th}}$  transmitter antenna to the  $j^{\text{th}}$  receiver antenna and  $n_i$  are noise signals for  $i,j=1,2$ .

3. (original) The 2 x 2 system of claim 2, wherein respective bit metrics calculated for first and second transmitted signal  $s_1$  and  $s_2$  are calculated using  $(\hat{s}_1, \hat{s}_2)$  as follows for  $s_1$

$$m_{1i}^0 = \min_{s_m \in S^0} (|r_1 - h_{11}s_m - h_{21}\hat{s}_2|^2 + |r_2 - h_{12}s_m - h_{22}\hat{s}_2|^2) |b_{1i} = 0)$$

$$m_{1i}^1 = \min_{s_m \in S^1} (|r_1 - h_{11}s_m - h_{21}\hat{s}_2|^2 + |r_2 - h_{12}s_m - h_{22}\hat{s}_2|^2) |b_{1i} = 1)$$

and for  $s_2$

$$m_{2i}^0 = \min_{s_n \in S^0} (|r_1 - h_{11}\hat{s}_1 - h_{21}s_n|^2 + |r_2 - h_{12}\hat{s}_1 - h_{22}s_n|^2) |b_{2i} = 0)$$

$$m_{2i}^1 = \min_{s_n \in S^1} (|r_1 - h_{11}\hat{s}_1 - h_{21}s_n|^2 + |r_2 - h_{12}\hat{s}_1 - h_{22}s_n|^2) |b_{2i} = 1)$$

and the bit metrics pairs  $(m_{1i}^0, m_{1i}^1)$   $(m_{2i}^0, m_{2i}^1)$  are sent to a respective first and second deinterleaver and a first and second Viterbi decoder for decoding, wherein  $b_{1i}$  and  $b_{2i}$  respectively is a bit in signal  $s_1$  and  $s_2$  for which a decision is being made.

4. (original) The 2x2 system of claim 2, wherein the demapping and signal separation module obtains a first and second constellation point,  $s_1^p$  and  $s_2^p$ , satisfying the minimum Euclidean distance from first and second transmitted signal  $\tilde{s}_1$  and  $\tilde{s}_2$  for bit  $i$

$$\min_{s \in S_i^p} \| \tilde{s}_q - s \|^2$$

where  $q = 1, 2$  and  $S_i^p$  represents the subset of a constellation point set for bit  $i$ , the bit for which a decision is being made, such that  $p \in \{0,1\}$ , uses these constellation points as input to a maximum likelihood calculation in the form of a bit metrics calculation for  $p=0,1$

$$m_{1i}^p = (\| r_1 - h_{11}s_{1i}^p - h_{21}\hat{s}_2 \|^2 + \| r_2 - h_{12}s_{1i}^p - h_{22}\hat{s}_2 \|^2)$$

$$m_{2i}^p = (\| r_1 - h_{11}\hat{s}_1 - h_{21}s_{2i}^p \|^2 + \| r_2 - h_{12}\hat{s}_1 - h_{22}s_{2i}^p \|^2)$$

and the bit metrics pairs  $(m_{1i}^0, m_{1i}^1)$   $(m_{2i}^0, m_{2i}^1)$  are sent to a respective first and second deinterleaver and a first and second Viterbi decoder for decoding.

5. (original) The 2x2 system of claim 2, wherein the demapping and signal separation module performs a slice-compare-select operation to determine a first and second constellation point,  $s_{1i}^p$  and  $s_{2i}^p$ , corresponding to the ZF signal which first and second constellation point is used as input to a maximum likelihood calculation in the form of a bit metrics calculation for  $p=0,1$

$$m_{1i}^p = (\| r_1 - h_{11}s_{1i}^p - h_{21}\hat{s}_2 \|^2 + \| r_2 - h_{12}s_{1i}^p - h_{22}\hat{s}_2 \|^2)$$

$$m_{2i}^p = (\| r_1 - h_{11}\hat{s}_1 - h_{21}s_{2i}^p \|^2 + \| r_2 - h_{12}\hat{s}_1 - h_{22}s_{2i}^p \|^2)$$

and the bit metrics pairs  $(m_{1i}^0, m_{1i}^1)$   $(m_{2i}^0, m_{2i}^1)$  are sent to a respective first and second deinterleaver and a first and second Viterbi decoder for decoding.

6. (currently amended) The 2 x 2 system of claim [1] 2, wherein said first and second SISO system is based on a 54Mbps IEEE 802.11a SISO orthogonal frequency division multiplexing (OFDM) system.

7. (withdrawn) A decoder for a 2 x 2 coded orthogonal frequency division multiplexing-multiple input multiple output (COFDM-MIMO) system, comprising:

a demapping and signal separation module to develop a first and second bit metrics pair based on zero forcing guided maximum likelihood (ML) decoding of a first and second received signal  $r_1$  and  $r_2$  that correspond to a first and second transmitted signal  $s_1$  and  $s_2$  respectively transmitted and received by said 2 x 2 COFDM-MIMO system; and

a first and second deinterleaver and Viterbi decoder adapted to receive said first and second bit metrics pairs, respectively, for forward error correction decoding thereof, wherein said decoder enables a transmission rate that is double the transmission rate of an optimal 54Mbps SISO system to 108Mbps at a decoding computation cost comparable to that of the optimal 54Mbps SISO system.

8. (withdrawn) The decoder of claim 7, wherein the demapping and signal separation module employs zero forcing (ZF) of the first and second received signal, respectively, which received signals correspond to

$$\begin{pmatrix} r_1 \\ r_2 \end{pmatrix} = \begin{pmatrix} h_{11} & h_{21} \\ h_{12} & h_{22} \end{pmatrix} \begin{pmatrix} s_1 \\ s_2 \end{pmatrix} + \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}$$

and results in the first and second transmitted signal being calculated as

$$\begin{pmatrix} \tilde{s}_1 \\ \tilde{s}_2 \end{pmatrix} = \begin{pmatrix} h_{11} & h_{21} \\ h_{12} & h_{22} \end{pmatrix}^{-1} \begin{pmatrix} r_1 \\ r_2 \end{pmatrix}$$

and finds the minimum Euclidean distance between the ZF calculated symbol and a constellation point to estimate by hard decision the first and second transmitted signal as first and second estimated signal as  $\begin{pmatrix} \hat{s}_1 \\ \hat{s}_2 \end{pmatrix}$  which are then used to guide the maximum

likelihood (ML) decoding,

wherein,  $h_{ij}$  represents a channel from the  $i^{\text{th}}$  transmitter antenna to the  $j^{\text{th}}$  receiver antenna and  $n_i$  are noise signals for  $i,j=1,2$ .

9. (withdrawn) The decoder of claim 8, wherein the demapping and signal separation module (34) calculates respective bit metrics for first and second transmitted signal  $s_1$  and  $s_2$  using  $\begin{pmatrix} \hat{s}_1 \\ \hat{s}_2 \end{pmatrix}$  as follows for  $s_1$

$$m_{1i}^0 = \min_{s_m \in S^0} ((|r_1 - h_{11}s_m - h_{21}\hat{s}_2|^2 + |r_2 - h_{12}s_m - h_{22}\hat{s}_2|^2) | b_{1i} = 0)$$

$$m_{1i}^1 = \min_{s_m \in S^1} ((|r_1 - h_{11}s_m - h_{21}\hat{s}_2|^2 + |r_2 - h_{12}s_m - h_{22}\hat{s}_2|^2) | b_{1i} = 1)$$

and for  $s_2$

$$m_{2i}^0 = \min_{s_n \in S^0} ((|r_1 - h_{11}\hat{s}_1 - h_{21}s_n|^2 + |r_2 - h_{12}\hat{s}_1 - h_{22}s_n|^2) | b_{2i} = 0)$$

$$m_{2i}^1 = \min_{s_n \in S^1} ((|r_1 - h_{11}\hat{s}_1 - h_{21}s_n|^2 + |r_2 - h_{12}\hat{s}_1 - h_{22}s_n|^2) | b_{2i} = 1)$$

wherein  $b_{1i}$  and  $b_{2i}$  respectively is a bit in signal  $s_1$  and  $s_2$  for which a decision is being made.

10. (withdrawn) The decoder of claim 8, wherein the demapping and signal separation module obtains a first and second constellation point,  $s_{1i}^p$  and  $s_{2i}^p$ , satisfying the minimum Euclidean distance from first and second transmitted signal  $\tilde{s}_1$  and  $\tilde{s}_2$  for bit  $i$

$$\min_{s \in S_i^p} \| \tilde{s}_q - s \|^2$$

and uses these constellation points as input to a maximum likelihood calculation in the form of a bit metrics calculation for  $p=0,1$

$$m_{1i}^p = (\| r_1 - h_{11}s_{1i}^p - h_{21}\hat{s}_2 \|^2 + \| r_2 - h_{12}s_{1i}^p - h_{22}\hat{s}_2 \|^2)$$

$$m_{2i}^p = (\| r_1 - h_{11}\hat{s}_1 - h_{21}s_{2i}^p \|^2 + \| r_2 - h_{12}\hat{s}_1 - h_{22}s_{2i}^p \|^2)$$

wherein,  $q = 1, 2$  and  $S_i^p$  represents the subset of a constellation point set for bit  $i$  such that  $p \in \{0,1\}$ , and bit  $i$  is the bit for which a decision is being made.

11. (withdrawn) The decoder of claim 8, wherein the demapping and signal separation module performs a slice-compare-select operation to determine a first and second constellation point,  $s_{1i}^p$  and  $s_{2i}^p$ , corresponding to the ZF signal which are then used as input to a maximum likelihood calculation in the form of a bit metrics calculation for  $p=0,1$

$$m_{1i}^p = (\| r_1 - h_{11}s_{1i}^p - h_{21}\hat{s}_2 \|^2 + \| r_2 - h_{12}s_{1i}^p - h_{22}\hat{s}_2 \|^2)$$

$$m_{2i}^p = (\| r_1 - h_{11}\hat{s}_1 - h_{21}s_{2i}^p \|^2 + \| r_2 - h_{12}\hat{s}_1 - h_{22}s_{2i}^p \|^2)$$

12. (withdrawn) A decoding method for a 2 x 2 coded orthogonal frequency division multiplexing multiple input multiple output system, comprising the steps of:  
 transmitting by said 2 x 2 system a first and second transmitted signal;  
 receiving by said 2 x 2 system a first and second received signal that correspond to said first and second transmitted signal;  
 developing a first and second bit metrics pair based on zero forcing guided maximum likelihood (ML) decoding of said first and second received signal; and  
 deinterleaving and decoding said first and second bit metrics pairs to obtain a first and second decoded signal,  
 wherein said decoder enables a transmission rate that is double the transmission rate of an optimal 54 Mbps single input single output SISO system to 108Mbps at a decoding computation cost comparable to that of the optimal 54 Mbps SISO system.

13. (withdrawn) The decoding method of claim 12, wherein said developing step further comprises the steps of:  
 separating the first and second received signal into a first and second separated signal;

obtaining by hard decision a first and a second constellation point which is respectively closest to the first and second separated symbol;  
with the second constellation point fixed, calculating the first bit metrics pair using ML criteria and the first separated signal; and  
with the first constellation point fixed, calculating the second bit metrics pair using ML criteria.

14. (withdrawn) The decoding method of claim 12, wherein said developing step further comprises the steps of:

separating the first and second received signal into a first and second separated signal;  
obtaining a first and second constellation point which satisfies the minimum Euclidean distance from the first and second separated signal; and  
calculating a first and second bit metrics pair using the first and second constellation point as input to a maximum likelihood calculation.

15. (withdrawn) The decoding method of claim 12, wherein said developing step further comprises the steps of:

separating the first and second received signal into a first and second separated signal;  
obtaining a first and second constellation point corresponding to the separated signal by a slice-compare-select operation; and  
calculating a first and second bit metrics pair using the first and second constellation point as input to a maximum likelihood calculation.